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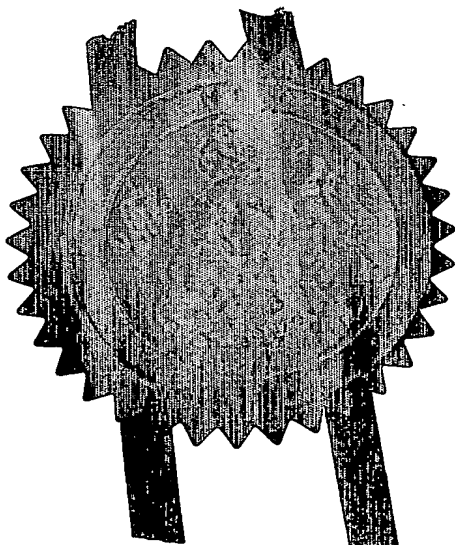
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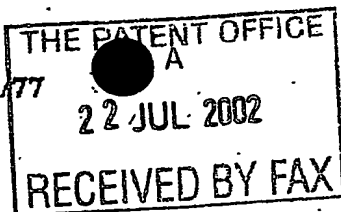
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2.	Patent application number (The Patent Office will fill in this part)	0216885.4 22 JUL 2002		
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Description 19

Claim(s)

Abstract

Drawing(s)

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*TIP Dummett*  
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TITLE: METHOD

The present invention relates to a method, notably to a method for making printing transfers.

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BACKGROUND TO THE INVENTION:

Transfers used for applying an image to a substrate typically comprise a carrier sheet or web having applied thereto an image and a cover coat which overlies the image and usually extends radially beyond the periphery of the image. The term image is used herein to denote any form of image, for example a decorative picture or pattern, an alphanumeric batch or quality control code, a product name or code and so on. The image may be a complete individual image or may be composed of a series of separate elements which make up a total image, as is the case for example with a pattern for the rim of a plate which may comprise a series of separate elements in a specified spatial relationship and orientation to one another. The cover coat serves to retain the integrity of the image when the image is transferred from the carrier to the substrate to which it is desired to apply the image. For example, the cover coat can extend over a series of elements of an image to ensure that they are retained in the desired relationship to one another as the transfer is applied to the substrate. The cover coat may then remain upon the substrate to protect the image or may be removed. For example, in applying images to ceramic articles, the image is applied to the article and the article then heated to

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fire the image to the surface of the article and to burn off the cover coat.

For convenience, the term transfer will be used herein to  
5 denote in general all types of such a structure for any  
use. However, the invention is of especial application in  
the manufacture of transfers for use in applying an image  
to a ceramic article which is then heated to remove the  
cover coat. The invention will be described hereinafter  
10 in terms of this preferred application.

In current practice, the image and the cover coat are  
applied to the carrier sheet or web, for convenience  
generally denoted hereinafter as the carrier sheet, by  
15 consecutive lithographic or screen printing operations.  
This usually requires the use of a drying stage between  
the application of the image and the cover coat, which  
adds to the time and cost of manufacturing a transfer.  
Such consecutive printing also requires accurate  
20 registration of the application of the cover coat to the  
carrier sheet in order to ensure correct application of  
the cover coat over that area of the carrier sheet  
carrying the image. This can be complex and costly and is  
often prone to errors. Alternatively, the cover coat is  
25 applied over the whole surface of the carrier sheet, in  
which case problems of registration are reduced, but  
wastage of the cover coat occurs.

Furthermore, the printing techniques used are appropriate  
30 for large scale runs of the same image and cover coat

patterns. However, the use of transfer printing of images is not economically viable for short runs, except for high value products where the cost of designing and creating the necessary individual screens or printing plates for the image and cover coat printing can be accepted. As a result, short runs of a printed ceramic article, for example a commemorative plate or cup, are expensive and complex to achieve and often result in a high level of faulty products due to imperfect registration of the printed image on the substrate, notably where the article has a complex three dimensional surface shape.

Furthermore, printing screens are complex and costly to design, fabricate and maintain and are prone to contamination, leading to defects in the application of the image or cover coat, and to retention of residual image-forming or cover coating compositions leading to dribbling of residual composition onto the carrier sheet.

We have now devised a method which reduces these problems and permits short runs of a product to be achieved economically.

#### SUMMARY OF THE INVENTION:

Accordingly, the present invention provides a process for manufacturing a transfer for application to a substrate, notably to the surface of a ceramic article which is then to be heated to fire the image to the article and remove the cover coat, which method comprises applying an image

to a carrier sheet and applying a cover coat over at least that area of the sheet to which the image has been applied, characterised in that the image and/or the cover coat is applied using a drop on demand or impulse jet ink jet printer.

Surprisingly, we have found that such ink jet printers can be used successfully to apply the pigmented image-forming compositions and the viscous cover coat compositions to the carrier sheet of a transfer. This is despite the fact that it is known that ink jet printers are not suitable for applying highly pigmented or highly viscous materials and prima facie would not have been considered as possible mechanisms for applying the image and/or cover coat compositions.

The ability to use an ink jet printer to apply the image-forming composition and/or the cover coat enables the print operator to change the image and the shape of the cover coating rapidly on line with minimal disruption of the transfer production process. This enables short production runs of transfers to be achieved economically. Since the image printed is changed by altering the operation of the printer using electronic control techniques, the operator avoids the cost and complexity of changing screens and of ensuring accurate registration of the printed image and cover coat following a change of image.

Furthermore, many of the compositions which can be applied

using an ink printer often dry rapidly. It may thus be possible using the method of the invention to do away with the need for the large and expensive drying tunnels hitherto considered essential in the manufacture of  
5 transfers.

We have also found that the use of such ink jet printers reduces the dribbling of image-forming or cover coat compositions onto the carrier sheet or between printed  
10 images which occurs with screen printing techniques. The image produced using such ink jet printers are thus often sharper than those achieved using conventional screen printing techniques.

15 As indicated above, the invention is of especial application in the manufacture of transfers for application to ceramic articles where the cover coat is subsequently removed from the applied image by firing or heating the article. However, the invention may be  
20 applied to the manufacture of transfers for any use where the benefits of being able to change the image rapidly and/or on line can be of benefit, for example in the manufacture of decal transfers for the automotive industry, for the manufacture of product identification  
25 labels in the electronics or other industries and so on. In such other applications the cover coat may remain in position overlying the image once it has been applied to the target substrate to act as a protective layer. However, in all cases the initial function of the cover  
30 coat is to retain the integrity and orientation of the



elements of the image over which it has been applied. Therefore, the cover coat typically extends beyond the plan area of the image. Since the ink jet printer can apply the cover coat composition to an accurately  
5 designated area, it can apply the cover coat only to those discrete areas of the carrier sheet carrying an image or elements forming an overall image, rather than over the whole area of the sheet. Typically, the cover coat extends from 0.5 to 2 mms beyond the periphery of the  
10 image and may provide a bridging layer extending between individual elements of a composite image. For convenience, the invention will be described hereinafter in terms of a single image element having a single cover coat applied so that it extends substantially uniformly  
15 approximately 1 mm beyond the edges of the image.

The carrier sheet component of the transfer structure can be made from any suitable material, for example a siliconised paper or card, from which the image can  
20 readily be separated and can take any suitable form, for example a sheet, or strip which acts as a support or carrier for the image and cover coating. Typically, the image is floated off the carrier sheet using water and the carrier sheet is made from a water resistant material.  
25 Many types of suitable material are used in the transfer manufacturing industry and may be used in the present invention. A particularly preferred material for present use is

30 For convenience, the invention will be described

hereinafter in terms of the use of a sheet of a siliconised paper as the carrier sheet.

5 The image forming composition applied to the carrier sheet is typically a suspension of one or more suitable pigments in a fluid carrier. However, dyestuffs which are soluble dispersible or emulsify-able in the fluid carrier may also be used. Where the transfer is to be used in the ceramic industry, the pigments, dyestuffs or other colouring agents need to be stable under the conditions to which the transfer is subjected during firing of the transfer to remove the cover coat. Typically, the pigments or other image forming agents will be colouring agents.

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15 If desired, the image-forming agent may be a mixture of materials, for example solid particulate pigments and fusible waxes or dyes. If desired, one or more of the components of the image-forming composition may undergo interaction, for example during the heating operation, to form a different colour and/or to set or gel, as would be the case with a UV cured ink. For convenience, the invention will be described hereinafter in terms of a single image-forming ingredient which is a particulate solid suspended in a fluid carrier medium. However, it

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25 will be appreciated that different compositions may be applied through different nozzle orifices in the ink jet printer head to achieve a desired colour image or overprinting of the image-forming compositions to form a complex image.

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The image-forming composition may be a water and/or organic solvent based composition and may contain any suitable proportions of pigment or other colouring agent to fluid carrier medium. However, the fluid carrier  
5 medium may be a fusible material, for example a micro-crystalline or other natural or synthetic wax, which melts upon heating to provide a fluid composition for application to the carrier sheet. However, it will usually be preferred to use a composition which is fluid  
10 at room temperature and typically the fluid carrier will be water and/or an organic solvent or diluent. Typical of such fluid carriers are lower alkanols, ketones or esters such as ethanol, propanol or butanol; lower alkyl ketones such as acetone or methylethylketone; and lower alkyl  
15 esters of monocarboxylic acids such as ethyl acetate. If desired mixtures of such solvents can be used, for example mixtures of ethanol acetone and ethylacetate, optionally in admixture with minor or major proportions of water.

20 The optimum fluid carrier for the image-forming composition may readily be determined by simple trial and error tests having regard to the nozzle or other orifice of the ink jet printer through which the composition is to be applied. Typically, the image-forming composition will  
25 be applied at a pressure of up to 3 Bar through a nozzle orifice of up to 500 micrometres and this will usually require that the composition have a viscosity of less than about 250 cPs at 25°C, typically less than 125 cPs. If desired the proportions of image-forming component and  
30 fluid carrier can be adjusted to achieve a viscosity

within the limits required by the specific ink jet printer to be used.

For convenience, the invention will be described hereinafter in terms of the application of an image-forming composition containing to parts of a solid pigment suspended in 100 parts of methylethylketone carrier.

10 If desired, the image-forming composition may also contain suspension or emulsion stabilisers, viscosity modifiers and/or film-forming binders or polymers known in the ink jet printing art.

15 The cover coat composition is typically a film-forming composition containing a polymer in a fluid carrier. The polymer is typically an acrylate, alkyacrylate, vinyl, carbonate, styrene, or alkene polymer, copolymer, mixture, blend or alloy or a synthetic rubber, for example a  
20 butadiene/acrylate or styrene blend.

The fluid carrier is typically water or an organic solvent of the types described above for use in the image forming composition. Preferred cover coat compositions for use in  
25 the ceramics industry contain a film-forming polymer which decomposes to give volatile components upon heating and/or the polymers are thermally stable but sublime and/or volatilise when the transfer is heated. Typically such decomposition or volatilisation occurs at a temperature  
30 which is at least 20°C below the temperature required to

fire the image forming components to the glaze of the ceramic article to which the transfer has been applied. The cover coat serves to protect the image on the transfer and to retain the integrity of the image as the image is transferred from the carrier sheet to the ceramic article. 5 The cover coat must therefore have sufficient tensile strength to achieve this function. This can be achieved by the use of polymers which have the requisite strength in thin films and/or by the application of a sufficiently thick cover coat film, for example from 20 to 50 micrometres thick, to achieve the desired tensile strength. 10

It will usually be desired to use the minimum of film forming polymer in the cover coat from cost considerations, for example to form a film about 30 micrometres thick. The optimum polymer and film thickness used in any given case can readily be determined by simple trial and error tests. 15

20 As with the image-forming composition, the maximum viscosity of the cover coat composition will also be determined by the type of ink printer used to apply the composition. Typically, the cover coat composition will 25 have a viscosity of less than 250 cPs at 25°C, preferably less than 125 cPs, and will be applied at a pressure of about 3 Bar through a nozzle orifice of from 200 to 500 micrometres.

30 A particularly preferred cover coat composition is one

comprising the film-forming polymer dissolved or suspended in 100 parts of a fluid carrier composition comprising water and/or an organic solvent such as methylethyl ketone.

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In the method of the invention, the image-forming composition and/or the cover coat composition, preferably both, are applied using a drop on demand or impulse jet ink jet printer. In view of the high viscosities of the compositions, it is preferred to use a drop on demand ink jet printer which is capable of operating at pressures of up to 3 to 5 Bar using nozzle orifices of from 200 to 500 micrometres. Such printers and their operation are known in the printing field and are commercially available from Willett Limited and may be used in their commercially available forms with little or no modification. Such printers typically comprise an array of nozzle orifices in a print head past which a carrier sheet travels. Each nozzle is fed with image-forming or coating composition under the control of a valve mechanism, notably an electrical solenoid valve opened and shut by applying an electrical pulse to the appropriate valve. In this way the sequence of operation of the valves deposits image-forming or cover coating composition at the desired location on the carrier sheet moving relative to the print head. As indicated above, a series of nozzles and/or print heads can be used to deposit several different image-forming compositions to create a complex image on the carrier sheet.

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The drop on demand printer can be operated in the conventional manner. However, we have found that in some circumstances due to the high viscosity of the compositions being applied, it may be desirable to apply a  
5 double electrical pulse to the solenoid valve in place of the conventional single pulse to open the valve for each printed dot. Such double pulsing of the valve can be achieved using conventional techniques. Furthermore, when applying the cover coat it may be desired to hold the  
10 valve open for prolonged periods to print continuously from a given nozzle, that is to hold the valve open for longer than three consecutive printed dots. In this case it may be desired to apply an initially high electrical pulse to open the valve and then to retain the valve in  
15 the open position by applying a holding electrical current to the valve which is only 20 to 40% of the initial current level. This reduces the risk of overheating of the valve and premature burnout of the solenoid valve.

20 As indicated above, the drop on demand printer used in the method of the invention may be a commercially available form of such a printer, except that it will usually be desired to use a nozzle having an orifice of from 125 to 500 micrometres so that the printer operates at pressures  
25 below about 3 Bar. However, a preferred form of drop on demand print head is one which operates at a frequency in excess of 1 kHz, preferably 2 to 4 kHz, since we have found that the use of such high frequencies enables high resolution images to be printed and that the use of such  
30 high frequencies avoids the need for the double pulsing of

the valve described above. In order to achieve such high frequencies of operation, it is preferred to form the plunger of the solenoid valve as a unitary construction and from an electro-magnetically soft material having a  
5 saturation flux density greater than 1.4 Tesla, preferably about 1.6 to 1.8 Tesla, a coercivity of less than 0.25 ampere per metre, and a relative magnetic permeability in excess of 10,000. It is also preferred that the nozzle  
10 bore leading from the valve head chamber of the valve to the nozzle orifice has a length to diameter ratio of less than 8:1, preferably from 1.5:1 to 5:1, notably from 2:1 to 4:1.

The term magnetically soft is used herein to denote that  
15 the material loses the magnetic field induced in it by the coil when the current in the coil ceases, in contrast to a permanent magnet which retains its magnetism. We have found that the use of the specified materials for the plunger overcomes many of the problems associated with the  
20 use of the conventional stainless steel plunger materials, for example Carpenter 430F, which have saturation flux densities of less than about 1.2 Tesla, coercivities of about 0.95 to 2 A/m and permeabilities of less than about  
25 3,000. We have found that the conventional materials generate excessive heat energy when reciprocated at frequencies of 1 Khz. The use of materials having high magnetic flux saturation densities enables the plunger to respond rapidly to changes in the magnetic field generated by the coil without the generation of excessive heat. The  
30 low coercivity of the plunger material also aids the rapid



rise and fall of the induced magnetic field within the plunger under the influence of the field generated as a current is passed through the coil at low applied coil currents. This, coupled with the high permeability of the material, enables a high magnetic drive force to be generated rapidly between the coil and the plunger. As a result, the plunger can be accelerated rapidly by the coil without the need to apply high drive currents to the coil, typically in excess of 20 amperes, as hitherto considered necessary. This again reduces the heat energy which is generated as the plunger is moved by the coil. The low coercivity also permits a reverse magnetic force to be generated rapidly by reversing the direction of the current in the coil. This reversed force can be used to slow down the movement of the plunger as it reaches either or both extremes of its travel. Such magnetic braking may be used in place of or in conjunction with the bias spring conventionally used to return the plunger to its rest position. The magnetic braking can also be used to reduce the impact of the plunger as it seats against the inlet to the nozzle bore. This not only increases the operating life of the plunger and seal components, but also reduces satellite droplet formation as the valve closes. However, it will usually be preferred that the valve mechanism comprises a pre-tensioned spring member to bias the plunger against the magnetic field generated by the coil so as to return the plunger to its rest position when an electric current is not applied to the coil.

We have found that these benefits are achieved to a

remarkable extent when the plunger is of low mass, for example when the plunger has a diameter of less than 2.5 mm, notably about 1 mm, and has a length to diameter ratio of more than 3:1, preferably from about 5:1 to 10:1.

- 5 As result, such valves can be used to form a compact print head which results in better definition in the printed image and the ability to form more sharply defined edges to the printed image. Furthermore, the use of high frequency valves enables a drop on demand ink jet printer
- 10 to print images on a fast moving substrate with reduced distortion of the printed image as compared to a conventional drop on demand printer. The use of such high frequency valves also permits an image to be printed with one or more un-printed lines or intervals between adjacent
- 15 areas of the image so that bleeding of colour between adjacent areas is reduced.

In the method of the invention, the image-forming composition is applied to the carrier sheet and the cover

20 coating applied over that image so that the cover coat extends about 1mm beyond the edge of the image. Typically, the image will require some time to dry to a sufficient extent for the cover coat to be applied over it without causing puckering, bleeding of the image into the

25 cover coat and other problems. It may therefore be desired to incorporate a drying step between the image application and cover coat application steps. Such drying steps include IR heating or hot air heating, or may occur spontaneously where the image-forming composition is cured

30 through IR radiation or by chemical interactions.

However, the image-forming composition often dries sufficiently rapidly due to the nature of its composition and/or by virtue of the fact that the ink jet printer inherently applies small droplets of the composition which  
5 present a high drying surface area. It may therefore be possible to omit any specific drying step and to allow a drying time in the transport of the carrier sheet between the printer applying the image-forming composition and that applying the cover coat. Typically, a drying time of  
10 less than 5 seconds is sufficient to ensure that the image is dry enough to accept the cover coat. As a result, the method of the invention does away with the need for the complex, bulky and expensive drying tunnels hitherto considered necessary in the conventional methods for  
15 manufacturing transfers. In some cases it may be possible to carry out both the image printing and cover coat application with a single print head, for example where the image-forming composition is cured by UV radiation and it is desired to retain the cover coat upon the printed  
20 image as a protective over layer.

Where the image printing and the cover coat application are carried out at separate stations, it will usually be necessary to provide some means by which the operation of  
25 the cover coat printer can be synchronised with that of the image printer. Such synchronisation can be achieved using timing marks upon the carrier sheet and photocells to detect the passage of those marks. Alternatively, the movement of the carrier sheet can be monitored by means of  
30 a shaft encoder on one or more of the drive shafts of the

carrier sheet transport mechanism and inter-linking the output from the shaft encoder(s) to the operation of the printers. Such inter-linking and synchronisation of the operation of the carrier transport and the printers can be  
5 achieved electronically.

As indicated above, the operation of the printers and the patterns which they print are controlled electronically so that they can readily be varied without the interruption and complexity of replacing screens or plates as with  
10 conventional printing techniques. The operations can be readily adjusted on line so that minor errors in registration or positioning of images and/or cover coats can be rectified on line by simple input from a keyboard  
15 or other control means. This electronic control also allows the form of the image to be varied rapidly and on line so that different transfers can be made with minimal interruption of the printing and coating operations.

20 The invention will now be illustrated by the following examples in which all parts and percentages are given by weight unless stated otherwise.

A transfer comprises a sheet of siliconised paper upon  
25 which are printed an image and a cover coating which extends over the image and for approximately 1 mm beyond the edge of the image. The image-forming composition consists of a suspension of particles of the film-forming polymer in a solution of Orasol black dye in  
30 methylethylketone. The cover coating composition consists

of a dispersion of a blend of butyl rubber (95 parts) and polymethylmethacrylate (5 parts) in methylethylketone and has a viscosity of 100cPs at 25°C.

- 5 The image-forming composition was applied to the carrier sheet using a Willett 700 drop on demand ink jet printer operating at a pressure of 2 Bar and having an array of nozzles with a nozzle orifice diameter of 250 micrometres to print a solid black square approximately 2 cms square.
- 10 The printed image was allowed to dry naturally as the carrier sheet travelled for about 10 seconds to the cover coat printer station where a film about 30 micrometres thick of the cover coating composition was applied by a Willett 700 drop on demand printer operated at 3 Bar and
- 15 using a nozzle orifice size of 250 micrometres. The cover coat extended substantially uniformly 1 mm beyond the edge of the image and dried to a solid film within 10 seconds. If desired a hot air drier may be used to assist drying and curing of the cover coat. During the above operation,
- 20 the shape and size of the image and its associated cover coat were changed to a 3 cm equilateral triangular shape by altering the sequence of actuation of the solenoid valves in the print heads. During the transition from the square to triangular shape about six transfers were lost
- 25 through mis-shaping of the printed images and cover coats.

With the above arrangement, a scanner can be provided to scan a desired pattern and the information from the scanner then manipulated using conventional image

30 processing technology to provide the data input to create

- 19 -

a new set of printer control instructions for the image printer and the cover coating printer.

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